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An experimental investigation on the effect of planar and curved conducting surfaces on the radiation, polarization and impedance properties of microstrip antennas

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Abstract The performance of a microstrip patch antenna in the presence of a conducting ground plane has been evaluated through experimentation and computer simulation In particular, the changes in the antenna characteristics such as input impedance, radiation pattern, beam width, axial ratio *etc*, of a diagonally fed almost square microstrip patch antenna have been investigated, the antenna being mounted perpendicular to a conducting plane Effect of both planar and cylindrical conducting plane has been considered Remedial measure has also been proposed for improving performance

Keywords Microstrip antenna, conducting plane, VSWR bandwidth

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1. Introduction

When a microstrip antenna is integrated as a part of a system, there may be situations where it is not possible to avoid the presence of a conducting plane, which is parallel to the broadside direction of radiation from microstrip antenna. This situation may practically arise in some of the cases where a system designer may try to accommodate the antenna in a manner as shown in the Figure 1 from other constrains of system design.

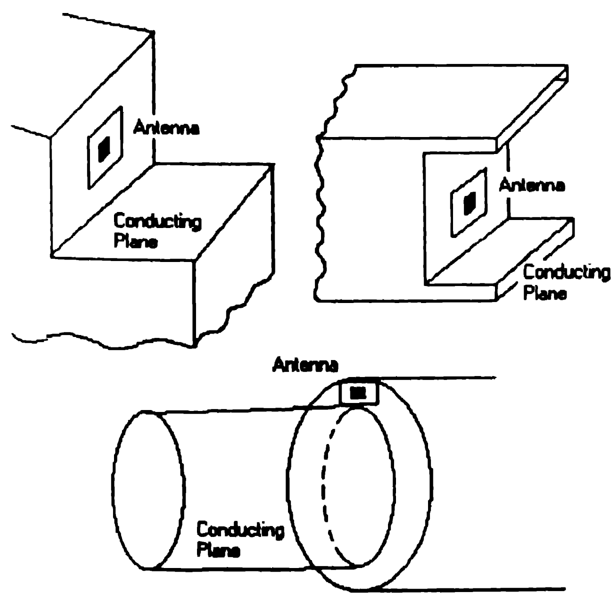

Figure 1. Microstrip patch antenna perpendicular to a conducting plane

This communication investigates the effect of such antenna placement on the performance of the antenna. The studies presented here include the effect of the conducting plane on the radiation (beam width, beam shape and axial ratio) and impedance characteristics of the antenna. Extensive experimentation was performed by mounting microstrip antennas on planar as well as cylindrical conducting surfaces.

2. Experimental results

The antenna used for performing the experimentation is a Diagonally Fed Approximate Square Patch Antenna (DFASPA) operating in the X-band [1–3]. The free space characteristics of the antenna are as shown in Figures 2 and 3.

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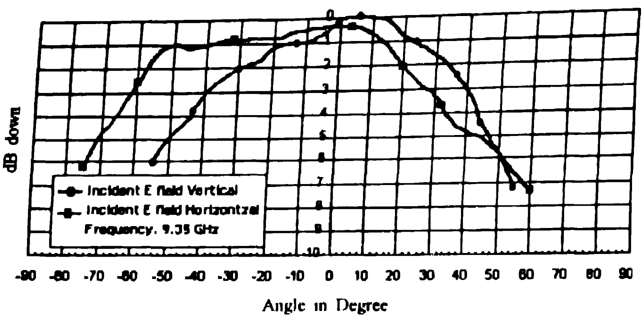

Figure 2. Free space radiation pattern of DFASPA

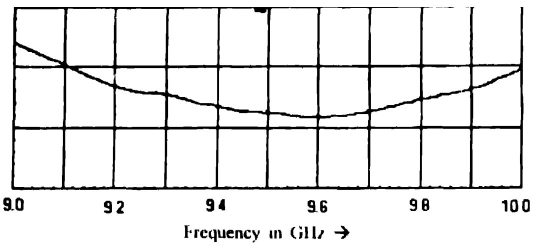

Figure 3. Free space VSWR pattern of DFASPA

The Figures 4 and 5 show the radiation pattern and VSWR plot of the antenna mounted on the middle of a conducting cylinder of diameter ~14 inches and length ~40 inches.

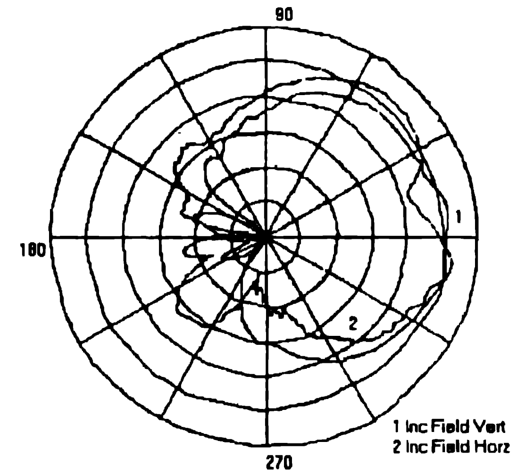

Figure 4. Radiation pattern of DFASPA placed on cylinder Null ~11dB and tilting of beam observed for incident *E*-field horizontal

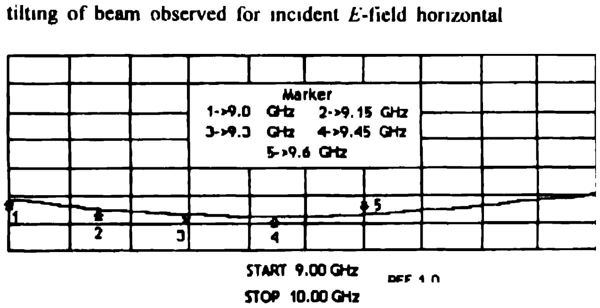

Figure 5. VSWR plot of DFASPA mounted on cylinder

From Figures 4 and 5, it can be seen that the beam shape for incident E-field vertical and the 2 : 1 VSWR band width is not effected significantly by the presence of the cylinder, the pattern for the incident E-field horizontal is affected severely. Similar observation can be made when the pattern measurement is repeated with a planar conducting sheet. The Figure 6 shows the measurement results.

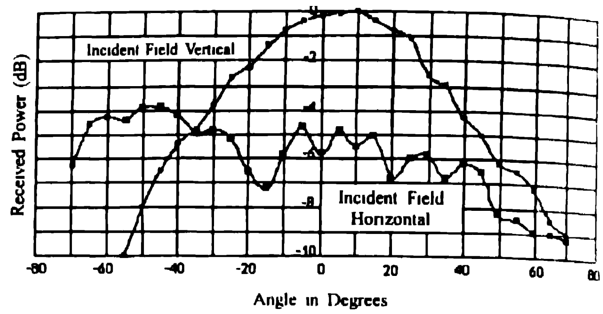

Figure 6. DFASPA on a conducting plane Pattern for incident *E*-field horizontal is irregular

3. Simulation results

The patterns of the said DFASPA without and with a conducting plane have also been simulated using HFSS from Ansoft Corporation. The problem geometry and simulation results are presented in Figures (7–9). The results are in

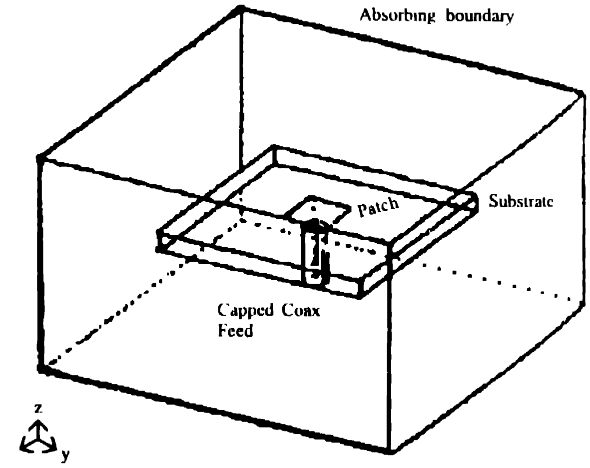

Figure 7. Patch antenna simulation (problem definition geometry)

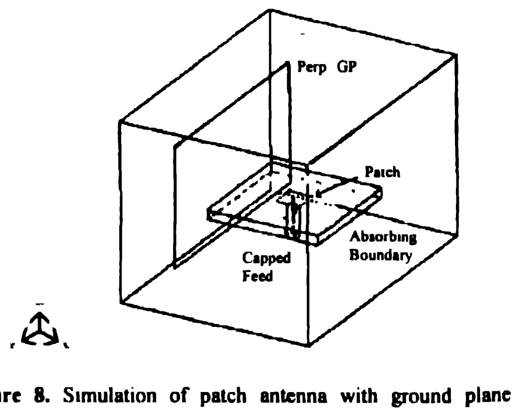

Figure 8. Simulation of patch antenna with ground plane (problem definition geometry).

agreement with our earlier experimental observation as can be seen from the Figure 9 where null as well beam tilting is observer for $\Phi = 90°$ pattern.

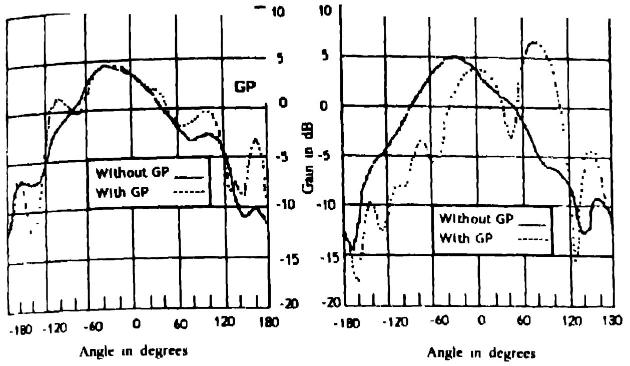

Figure 9. Radiation pattern in two perpendicular planes with and without ground plane

From the measurements and simulation, it can be inferred that a conducting surface perpendicular to the antenna plane severely affects the beam shape and axial ratio in the plane of the conductor. Radiation vertically polarized with respect to the conducting surface is not affected. Therefore DP and CP antennas cannot be operated near a conducting plane retaining the radiation properties

4. Suggested remedial measures

Performance improves considerably if the conducting plane is covered with absorbing material. A set of experiments was performed with the conducting plane covered with absorbing material. The results obtained are shown in Figure 10. The results are compared with that of free space measurements and measurements with conducting plane in Figures 11 and 12.

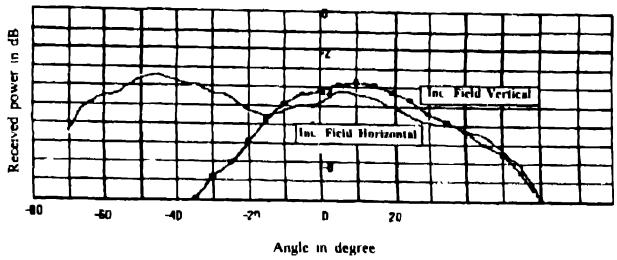

Figure 10. Radiation pattern with absorber cover

X-band diagonally fed approx square antenna Freq = 9.1 GHz Incident E-field vertical series 1 → antenna above conducting plane series 4 → antenna above conducting plane covered with absorbing sheet, series 6 → free space

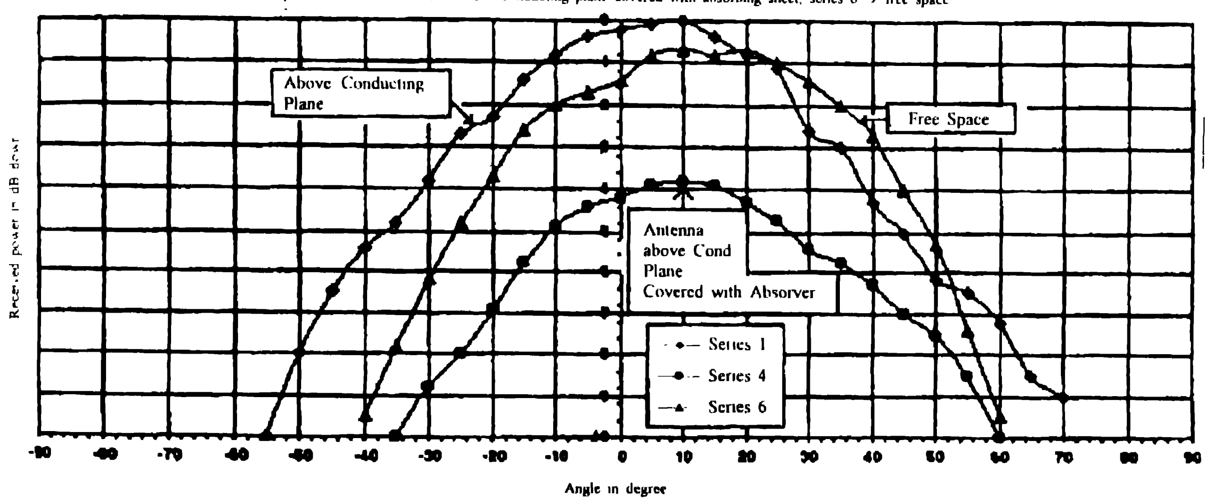

Figure 11. Comparison of pattern for incident E-field vertical

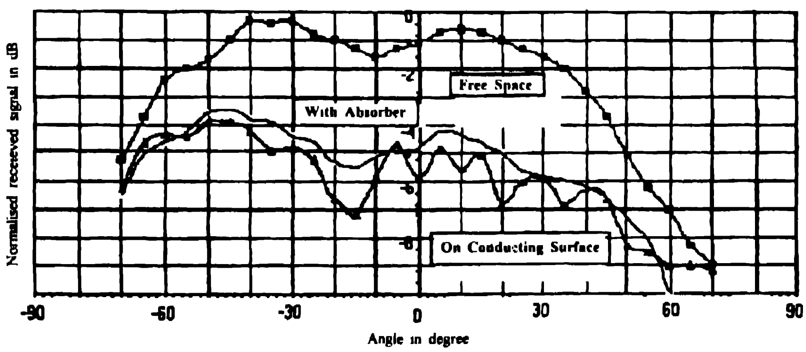

Figure 12. Comparison of pattern for incident E-field horizontal

5. Conclusions

The impedance and radiation properties of an almost square diagonally fed patch antenna mounted vertically on a conducting plane have been investigated both theoretically and experimentally. The results indicate that the radiation characteristics of the patch are drastically altered when mounted on a conducting surface as compared to its free-space values. But change in impedance properties as compared to its free-space characteristics is not significant. A remedial measure has also been suggested.

References

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